



Deconstructing a complex future: Scenario development and implications for the forest-based sector

Filip Aggestam^{a,*}, Bernhard Wolfslehner^b

^a European Forest Institute – Bonn Office, Resilience Programme, Platz der Vereinten Nationen 7, 53113 Bonn, Germany

^b European Forest Institute Central-East European Regional Office, Institute of Forest, Environmental, and Natural Resource Policy, University of Natural Resources and Life Sciences, Vienna, Feistmantelstr. 4, A-1180 Vienna, Austria



ARTICLE INFO

Keywords:

Scenario development
Forest policy
Forest management
Future studies

ABSTRACT

This paper set out to review future-oriented projects to determine how the use of scenarios may affect EU forest-related policy. The work was carried out as a desktop study, utilising online search engines and databases to select appropriate future-oriented projects for analysis. The screening resulted in 36 case studies, most of which focused on scenarios for the environment, biodiversity and climate change but also covering territorial development, urban development, energy and transport. Only 2 case studies focused exclusively on forests. Most scenarios were developed to provide policy recommendations, they have as such, irrespective of the approaches and storylines used, in many cases influenced policy developments in Europe. The clearest example being that of climate and energy policy targets. The results demonstrate that most scenario frameworks are still not generating integrative visions of the environment that include forests in its entirety, reflecting sectoral fragmentation at the EU level. Forest-related scenarios will have to become more integrative to explore opportunities for policy actions aiming for a more sustainable future. This would require that future scenarios coherently assess impacts across sectors and adequately address the wide (and increasing) range of demands being placed on our forest resources.

1. Introduction

Informed decision-making requires information from both past experiences and knowledge about the future. While the future can be difficult to predict, one way to analyse it is to use scenario-planning methods. Scenarios can be used to manage complexity and examine uncertainties over long time periods that allow researchers to more accurately perceive future possibilities (Chermack et al., 2001; Börjeson et al., 2006; Amer et al., 2013; den Herder et al., 2014), such as checking if targets will be met (e.g., carbon emission targets) or analyse cause-effect relationships (e.g., driving forces affecting forest ecosystems) (Rounsevell et al., 2006; Briner et al., 2012). Scenarios are a focus in this article as they also symbolise the priority-setting process. More specifically, scenarios are a reflection of sectoral, public and other development priorities (Kankaanpää and Carter, 2004; Bizikova et al., 2014; Joshi et al., 2015; Kröger and Schäfer, 2016), in particular as they explore possible, probable or preferable futures (Van Der Heijden, 1996, 2000; Carter and LA Rovere, 2001; Kok et al., 2007). Understanding the narratives being expressed through scenarios can consequently clarify how forests (both present and future) are perceived.

There are today many methods that are used to explore “preferable”

futures (e.g., increased biodiversity) or to plan for “probable” futures (e.g., climate change) as well as “possible” futures (e.g., high unemployment). Scenario planning is therefore a useful tool for practitioners and policy-makers in the forest-based sector as they help to structure and define future policy objectives, prepare strategies for varied future realities as well as identifying obstacles and/or opportunities presented by different future pathways (Godet and Roubelat, 1996; Porter et al., 1997; Roubelat, 2000). The premise for using scenarios is basically to reduce uncertainty and allow for policy-making based on the best available information and data. For the purposes of this paper, alternative future developments that will be pursued through policy provide a snapshot of prevailing societal preferences (e.g., sectoral, consumer, public) that will shape how forest resources may be utilised.

Scenario planning for the forest-based sector implies the development of a framework from which future socio-economic and environmental issues, such as land-use, spatial distribution of forests and landscape aesthetics can all be considered. For instance, climate change, land abandonment and rural depopulation are examples of drivers that may change the provision of ecosystem services (Verburg et al., 2006, 2010). Questions related to how these drivers remain

* Corresponding author.

E-mail address: filip.agggestam@efi.int (F. Aggestam).

prevalent (or if new drivers could emerge) is of central importance when considering future developments (Rounsevell et al., 2006; Setten and Austrheim, 2012; Kraxner et al., 2013). Scenarios are particularly relevant for the forest-based sector as it is dynamic and constantly affected by numerous (often conflicting) driving forces (e.g., agricultural practices, demographic change and the demand for renewable energy) that can interact in unpredictable ways (Briner et al., 2012). Decision making for forests is furthermore characterised by plans covering long time spans across various spatial scales implemented on the local, regional, national and international level (Wolfslehner and Seidl, 2010; Hoogstra-Klein et al., 2017). This means that forest-related scenarios should be capable of modelling long production periods in managed forests of 100 years and more, re-iterate changing environments (e.g., climate change), interact with changing societal demands on forests and be responsive to the needs of forest managers in anticipation of possible, probable or preferable developments. All of these factors combine to introduce a high degree of uncertainty (Kraxner et al., 2013; Hurmekoski and Hetemaki, 2013; den Herder et al., 2014; Seidl et al., 2016) and means that any scenario analysis is based on incomplete knowledge (Briner et al., 2012). This is inevitable (as the future is uncertain) but it emphasises the degree to which scenario planning is susceptible to biases as they build on existing knowledge, preferences and past experience (Franco et al., 2013; Bradfield et al., 2016).

A prospective view on forest management and scenario planning (Aggestam and Wolfslehner, 2013) provided the initial impetus for this paper which has the objective to review how scenarios relate to and affect the European forest-based sector. This forms the basis for the main question, namely, to answer how accurately scenarios reflect (or not) varying policy perspectives and what the implications may be for forest policy. This is a pertinent question for the forest-based sector in the European Union (EU) as it is a policy domain that is characterised by a lack of competence (Aggestam and Pülzl, 2018; Aggestam et al., 2017). This paper consequently differs from other scenario-related reviews (e.g. Amer et al., 2013; Hurmekoski and Hetemaki, 2013; den Herder et al., 2014; Hauck et al., 2015; Hoogstra-Klein et al., 2017) in that the emphasis is on the implications of scenario development for the forest-based sector rather than the purely technical aspects thereof.

2. Approach

The review of scenarios deemed relevant to the forest-based sector was carried out as a desktop study, utilising online search engines and databases to identify suitable case studies.

The first step focused on identifying such studies by means of screening online databases and libraries, such as: CORDIS (see <http://cordis.europa.eu>); the European Environment Agency (see <http://www.eea.europa.eu/publications>) and the United Nations Environment Programme (see <http://www.unep.org/publications/>). This screening of numerous projects and reports applied the following criteria:

- Completed within a set 15 year period (2000–2015 period).
- Dedicated at least one substantive section to scenarios and/or scenario development;
- Has a European and/or Pan-European focus¹;
- Has a significant degree of relevance for the forest-based sectors (see step 2).

Cases were identified using an iterative list of 17 search terms, including “forests”, “forest management”, “land-use”, “renewable energy”, “ecosystem services”, “nature conservation/restoration” and “biodiversity”,² with projects and/or reports also included iteratively

based on references in the literature. The outcome of this screening process can be found in Appendix A which presents a complete list of the selected projects and/or reports.

The second step of the analysis focused on determining the relevance of the collected material. This was achieved by posing three dichotomous (yes/no) questions:

1. Do forests occupy a central position in the project and/or report?
2. Does the issue of mountains and/or lowland areas occupy any position in the document?³
3. Does timber production, carbon sequestration, nature conservation or protection against gravitational hazards (or related topics) occupy any position in the document?

Each “yes” resulted in a point being added to the project and/or report and yielded a relevance score of 0 (no relevance) to 3 (high degree of relevance). The relevance score allowed the analysis to focus on a limited number of scenarios in relation to the study objectives and to rank the overall connection between the aim of the scenario and the forest-based sector. The final list of projects/reports thus utilised should for this reason not be considered as an exhaustive list.

The third step was to re-read and analyse all the prioritised documentation to define in more detail how the scenarios related to forests (e.g., energy and biodiversity focus), a process which entailed:

- Characterising the overall **purpose** the scenarios (e.g., thematic focus and aim).
- Defining the **driving forces** applied in all the scenarios (e.g., climate change or populations densities).
- Determining the **spatial** and **temporal scales** used in the scenarios (e.g., global scenarios covering the next 20 years).

Driving forces associated with the scenarios were documented using the STEEP typology, which covers socio-cultural, economic, environmental, technological and political driving forces. This provided a straightforward approach for categorising all the driving forces (Bowman, 1998). All the resultant information was then collated in an excel sheet to provide a concise overview of all the data from the analysis.

The fourth and final step focused on reviewing all the collected data on the scenarios (purpose, driving forces and spatial/temporal scales) to better understand how they are linked to forests and the forest-based sector. The objective was to determine the future pathways that respective scenarios can create for the forest-based sector (e.g., possible implications from a renewable energy perspective). This was a qualitative exercise designed to link the scenarios to EU policy and then explore the consequences that respective scenarios may have for forest-related policy-making in the EU.

3. Results and analysis

The results below are presented in two distinct parts. First, a brief introduction is provided highlighting some information on the types of and associated characteristics of the scenarios that were included in the analysis. Further information on this portion of the analysis can be found in Aggestam and Wolfslehner (2013). Second, and most importantly, how the scenarios are linked to the forest-based sector is clearly demonstrated.

(footnote continued)

“forecasting” during the screening, e.g., forests + scenarios.

³ Question 2 was specific to the project deliverable for which the data was originally collected. It has no direct relevance to the current paper (see Aggestam and Wolfslehner (2013)).

¹ Exceptions were made for projects and/or reports using internationally recognised scenario families.

² The search terms were also coupled together with “scenarios”, “foresight” and

3.1. Scenario studies and reports

The screening of scenarios as highlighted above resulted in the 36 cases (21 projects and 15 reports) listed in Appendix A & B. From the targeted 15 year period (2000–2015), the earliest project included is from 2001 and the latest is from 2014. The majority of the case studies focused on scenarios for the environment, biodiversity, climate change and sustainability with others focused on territorial development, urban development, energy and transport. It should be noted that the level of detail available on the respective scenarios varied greatly, ranging from being highly detailed to only providing an outline of the scenario, although these still provided sufficient information for meaningful analysis.

3.2. Types of scenarios

Several of the cases apply pre-existing storylines (or scenario families) such as the four marker storylines (A1, A2, B1 and B2) of the Intergovernmental Panel on Climate Change's (IPCC) special report on emission scenarios (Nakicenovic et al., 2000) or the four Global Environment Outlook 4 (GEO-4) scenarios on future global environmental changes (United Nations Environment Programme, 2007). These storylines (IPCC or GEO-4) are often adjusted to fit the specific purposes of the project or report. In the case of IPCC, this is frequently quantitative and model-based projections that are directly related to climate change. Examples of this are the ENSEMBLES, PLUREL and EFORWOOD models that adopted varying approaches, as well as the ATEAM model that adopted a more qualitative approach encompassing the narrative (or storyline) in the IPCC emission scenarios. In the case of the GEO-4 storylines, these are principally used for qualitative scenario-based analysis (or developments) by the respective case studies, often taking the form of narrative texts.

Aside from pre-existing scenario families, many projects developed baseline scenarios that are anchored in current trends or practice. Many terms other than “baseline scenario” are applied to these, such as “reference” scenarios in SCENAR 2020 and Mobility 2030, “business-as-usual” scenarios in BIOSCENE and Ecochange, or even the “best guess” scenarios in ELME, however their basic purpose remains the same. The driving premise here is that they all serve to mimic the current state-of-play as closely as possible, from which adjustments can then be made to project specific pathways into the future.

3.3. Driving forces of change

The purpose of categorising driving forces using the STEEP typology was to understand the general trend that the framework of driving forces depicts (e.g., economic development) rather than a detailed breakdown of each one (e.g., varied sectoral changes in economic growth). In most of the scenarios, driving forces play out differently for each future and can be seen as the symptom of the trend (or transformation) in each scenario. For example, in the SCENES project “Sustainability Eventually” scenario, climate change is a trend driven by strong top-down policies with impacts such as slow economic growth, water scarcity and increased/decreased migration. In contrast, in its “Policy Rules” scenario, climate change is a trend driven by the high costs associated with energy production and ineffective EU policies with impacts such as ecosystem services deterioration and urbanisation. Another example is the GEO-4 scenarios – market first, policy first, sustainability and security first – that each have distinct trends, drivers and impacts. The mechanisms underlying driving forces consequently vary across scenarios, depending on the cause-and-effect relationships that are emphasised (see Table 1).

One interesting finding is the inconsistent labelling of drivers, pressures and impacts across various scenarios. For example, climate change is in some scenarios seen as a pressure, where the drivers are anthropogenic factors (e.g., GHG emissions) with varying impacts from

increasing temperatures to changing rainfall patterns. In other scenarios, increasing GHG emissions is an impact, where the drivers are policy developments (e.g., industrial policy) affecting climate change through increased industrial activity. Another example of this scenario-specific use of drivers, pressures and impacts relates to flooding. In most scenarios flooding is characterised as an impact (e.g., caused by climate change), while in others, flooding is a driver that is causing an impact (e.g., changing policy responses). A general observation in this regard is that these differences often relate to the spatial scale of the scenario.

The varied drivers reflect the uncertainty implicit in what the future holds and provides a perspective of the future as seen at the time of a scenario's development, as can be exemplified by the 2008 financial crisis. Prior to the economic crisis, most scenarios unsurprisingly did not factor in a global financial meltdown, however afterwards, economic recovery (or stimulus) featured as a strong element in many scenarios (e.g. Ecochange and CAMELEON). This demonstrates the importance of time-specificity, the inherent uncertainty in developing a scenario and the importance of emergent policy priorities during scenario development.

3.4. Spatial and temporal scaling perspectives

Most of the scenarios used for this research operate on different spatial and temporal scales. To manage this variation the case studies were divided into three basic categories (global, EU and regional) with the categories only meant to be indicative of the scale that the scenarios focus on. In this instance, eight (or 22%) of the cases focused on global scenarios, 18 (or 50%) of the scenarios focused at the EU-level, and 10 (or 28%) cases focused on regional scenarios. For regional scenarios, this ranged from national to regional case studies in Europe, Asia, Africa and North America (see Appendix B). The spatial scale is for all scenarios adapted to the specific aim of each project or report. For instance, IPCCs four storylines (A1, A2, B1 and B2) or the GEO-4 scenarios or scenarios of the Netherlands Bureau for Economic Policy Analysis (CPB) provided a baseline that was often adapted to the national, regional or European level.

The cases were also divided into three temporal categories based upon their respective temporal scales, covering the near future (2020 to 2030), not too distant future (2040 to 2050) and the distant future (2080 to 2100). Table 2 demonstrates that the case study scenarios principally focus on the near future ($\approx 48\%$) or the not too distant future ($\approx 34\%$). Several projects do however cover 2 (or even 3) temporal scales within the same study. This corresponds to different storylines over a given time-period, rather than just presenting one moment in time.

3.5. Scenarios and the forest-based sector

The projects and reports included in the analysis can be noted to be predominantly Eurocentric since nearly all have been commissioned by European institutions. In some respects, this means that they also reflect the political reality for forests within the European sphere. Having this in mind, the scenarios present a fragmented image of forests, spread across different topics and sectors, such as transport, rural development and conservation (see Fig. 1). Only 3 ($\approx 8\%$) of the case studies (EFORWOOD, Forest Outlook Study and EUwood) dealt exclusively with forests while the vast majority focused on environmental (including biodiversity and ecosystems), climate and energy issues. However, most importantly for this paper, is the fact that most of these topics correspond to areas where the EU has legal competence.

Amongst the case studies that dealt directly with forests, two scenario categories can be readily distinguished. First, there are scenarios that are global (or cross-national), such as the GEO4, World Energy Outlook or Energy to 2050. These are scenarios that principally focus on cross-cutting topics (e.g., climate change and energy) over which the EU has no major influence. These case studies consider forests in a

Table 1
Examples of drivers under the STEEP categories.

Economic	Socio-cultural	Technological	Environmental	Political
⇒ Economic development	⇒ Urbanisation	⇒ Biotech & biomaterials	⇒ Climate change	⇒ Top-down policy programs
⇒ Growth in incomes	⇒ Migration	⇒ Productivity-enhancing technologies	⇒ Land-use	⇒ Decreasing societal solidarity
⇒ Free-market	⇒ Demographic change	⇒ Carbon sequestration technologies	⇒ Fragmentation	⇒ Erosion of the EU
⇒ Fractionalization of the global economy	⇒ Cultural ties to the land	⇒ Harvesting and processing technologies	⇒ Environmental degradation	⇒ Increasing/decreasing policy interventions
⇒ Economic insecurity	⇒ Informal institutions	⇒ Energy technologies	⇒ Population Growth & Density	⇒ Empowerment of local groups
⇒ Globalisation	⇒ Traditional knowledge		⇒ Changing age structures	⇒ Strong/weak coord. of policies at EU level
⇒ Poverty	⇒ Inequality			

Table 2
Spatial and temporal scales of the case studies.

		Temporal Scale			Total
		Near future	Not too distant future	Distant future	
Spatial scale	Regional	7 (15.9%)	7 (15.9%)	3 (6.8%)	17 (38.6%)
	EU 27	12 (27.3%)	5 (11.4%)	4 (9.1%)	21 (47.7%)
	Global	2 (4.5%)	3 (6.8%)	1 (2.3%)	6 (13.6%)
	Total	21 (47.7%)	15 (34.1%)	8 (18.2%)	

wider context, such as for mitigating and adapting to climate change. Second, there are scenarios for which the EU does have specific competences, such as for transport, agricultural and environmental issues. These scenarios consider forests within the framework of the case study in question. For instance, the EUwood wood supply scenarios focused on renewable energy, where the forest is seen as a commodity (e.g., supply of biomass for energy), hence reflecting how forest resources are perceived from an EU energy perspective.

The topical division is furthermore linked to most scenarios having a specific purpose in which forests are either the main focus or only a part of a bigger picture. From this topical perspective only 2 projects took what can be considered a holistic view on forests (EFORWOOD and Forest Outlook Study), while most cases adopted a multifunctional

perspective where forests were either broadly considered in terms of general land use (e.g., agriculture or conservations) or viewed from narrower perspective of specific forest functions (e.g., biomass or timber production). The absence of a holistic perspective on forests is also reflected in that only 10 projects and reports ($\approx 28\%$) can be considered as highly relevant for the forest-based sector, while the remaining case studies focused principally on topics either directly or indirectly related to forestry, such as infrastructure (e.g., Intelligent Infrastructure Futures), territorial future (e.g., ESPON) and marine ecosystems (e.g., ELME).

The highly relevant scenarios build on different assumptions about social, economic, political, technological and environmental changes that may take place. This implies that the challenges facing the forest-based sector vary significantly in accordance with a scenario's focus. For instance, climate change, technological progress, economic downturn (present and future) and population growth are frequently suggested as central drivers of change. Complex interrelationships and unpredictability exist between these varied driving forces and cause serious problems when attempting to explain how forests may look in the future. Examples include drivers that have varying effects in different forest areas (e.g., due to unique climatic, demographic and economic conditions), factors that can be both a driver and/or pressure (e.g., demographic pressure of an ageing population) or factors that change from being a driver to a pressure over time (e.g., economic growth). This means that the identification of generic drivers of change

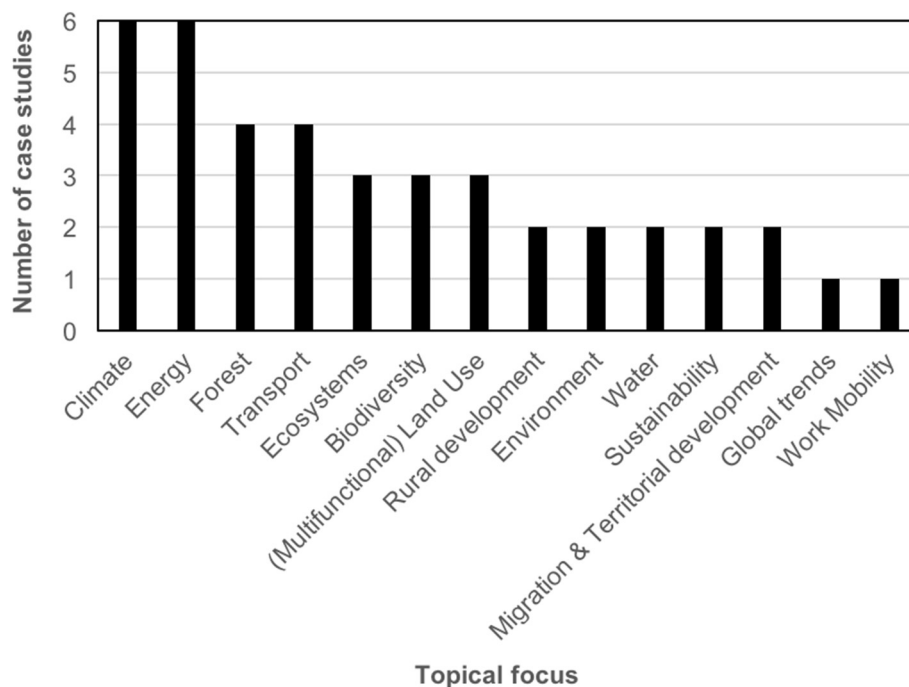


Fig. 1. Main focus areas of the case studies*.

* Some double counting as certain reports dealt with more than 1 main topic.

is challenging given the complex and fluid relationship between pressures, drivers and impacts over time. Furthermore, some of the case studies have developed scenarios that are too general to be useful in practice, lacking supporting analysis and quantification, making them not operational and irrelevant for policymaking. It can nevertheless be noted that most of the scenarios were developed to provide policy recommendations, such as for environmental conservation (e.g., Millennium Ecosystem Assessment), transport (e.g., Getting in the Right Lane for 2050) and energy (e.g., Shell Energy Scenarios to 2050).

Due to the necessary limitations imposed by adopting the workable approach taken in this paper, it is not possible to infer causal links with regards to the impact these scenarios may have had on policymaking. However, it can be reasonably presumed that the scenarios have had an effect on European forest-related policy-making. For example, the EUwood study has been utilised in the bioenergy discourse and has had an impact on EU policymaking in terms of setting targets for bioenergy and related perspectives of forests such as in the EU's energy and climate goals for 2030 (Council, 2014; European Commission, 2014). Perhaps most importantly, since the formulation of EU forest-related policy is based on the principle of subsidiarity and shared responsibility (Aggestam et al., 2017), it is mainly practitioners and policymakers in other sectors that think about and shape future forest utilisation. This highlights two main issues. The first issue has been repeatedly raised by forest policy researcher in the past, namely, that EU forest-related policy is fragmented and incoherent, a situation compounded if not driven by the lack of EU competence (Vogelpohl and Aggestam, 2011; Pülzl et al., 2013; Aggestam et al., 2017; Aggestam and Pülzl, 2018). This is clearly mirrored by the scenarios, more specifically, in the competencies they represent and commissioning institutions. The second issue concerns the implications inherent in scenario planning conducted principally by sectors other than the forest-based sector. Putting it more bluntly, forests do not have the leading voice concerning their own future to shape thinking at the EU level. The long-term effects of this may be significant, such as contradictory policies that are unworkable in practice, making the policy goals themselves unattainable (e.g., bioenergy targets) and neglecting apparent trade-offs (e.g., energy versus biodiversity conservation). This is clearly evidenced in the wide range of uncoordinated policy areas seen as having an impact on the forest-based sector (Aggestam et al., 2017; Aggestam and Pülzl, 2018).

4. Discussion

This paper has explored some of the future pathways that scenarios can create for the EU forest-based sector. It is a relevant topic since scenarios are used to deconstruct complex environments into more manageable building blocks that make sense of our natural systems and provide increased understanding of what the future may hold. This then facilitates more effective planning to find ways to prepare for the changes and challenges that will inevitably come. Although this study remains largely descriptive, it showcases that scenarios continue to play an important role for the forestry sector community, not only in science and applied research, but also in supporting policy-making, including the use of climate change scenarios in both policy-making (Mayerhofer et al., 2002; EEA, 2007, 2009; Keough and Shanahan, 2008; den Herder et al., 2014) and in forest modelling (Frittaion et al., 2011; Seidl et al., 2011; Kraxner et al., 2013; Seidl et al., 2016). Scenarios are effectively used to narrow and define the space in which decisions regarding forest-related policy-making are made and are consequently an essential part of the equation that will determine how forest resources are utilised in the future. An example of this would be scenarios that emphasise energy production that are reflected in policy, both in terms of laws and regulations (e.g., renewable energy targets) as well as the institutions that fund specific projects or reports. This would include scenario-based changes in timber production or actions taken to sequester carbon that have knock-on effects for other land use

relationships and ecosystem services, such as provisioning services (e.g., soil-mediated ecosystem services) that in turn affect climate regulation, urbanisation processes, water supply, and so on. In a nutshell, the way our future is being constructed or imagined is having a real world impact on forest cover and composition.

The policy implications from these results are clear. Most scenarios were developed to provide policy recommendations based on future pathways that would allow us to reach the best possible outcome, such as for climate change mitigation or biodiversity conservation. This means that the majority of the scenarios reflect the perspectives and needs of underlying policy frameworks, which also echoes the lack of a legal basis for forests at EU level. To put the concern here more bluntly, EU policymakers may be construing a future where forests are not taken into account adequately with the IPCC scenarios being but one example of this. By having different climate projections, the IPCC scenarios have played a central role in EU climate target setting and policymaking, such as the 2020 climate and energy package (European Commission, 2009) and the 2030 framework for climate and energy policies (Council, 2014; European Commission, 2014). IPCC scenarios have thus provided inputs into policy formulation and the development of policy measures (e.g., climate change adaptation) as well as strategic developments (e.g., vision documents) that influence forest management. The lack of a common forest policy in Europe may be partly to blame for the low number of scenarios that take a holistic view on forests, however and perhaps more importantly, the results demonstrate how a single-sector's interests can dominate the creation of a vision that will significantly affect another sector, in this case the forest-based sector.

The apparent danger in having a single-sector approach rather than one involving integrated multi-sector input into scenario development is that models born from individual sectors (such as the agricultural sector) are applied without considering interactions between sectors. This reflects the fact that scenarios often neglect the conflicting demands that are being placed on forest resources (Briner et al., 2012; Kraxner et al., 2013; Hetemäki, 2014), such as biodiversity conservation, carbon sequestration and forests as a source of renewable energy. This also mirrors the already mentioned fragmentation and incoherence that one finds in EU forest-related policy (Vogelpohl and Aggestam, 2011; Pülzl et al., 2013; Aggestam et al., 2017; Aggestam and Pülzl, 2018) and may lead to both the misrepresentation of impacts and poor policy-making. A case in point is a recent study by Harrison et al. (2016) which demonstrated that single-sector studies misrepresent the spatial pattern, direction and magnitude of most impacts because they omit the complex interdependencies within human and environmental systems. This emphasises the danger of operationalising sectoral oriented visions through policy (e.g., conflicting target setting) that do not consider forests in a holistic manner and thus supports the notion that sectoral boundaries (or barriers) need to be broken down. Forest-related scenarios will essentially have to become more integrative if they wish to explore sustainable opportunities for policy action (Joshi et al., 2015; Kröger and Schäfer, 2016; Harrison et al., 2016; Maier and Winkel, 2017). Future scenario development needs to coherently assess impacts across sectors and adequately address the wide (and increasing) range of demands being placed on forest resources.

Acknowledgements

This study was conducted within the framework of the ARANGE (Advanced multifunctional forest management in European mountain ranges) project, funded under the 7th Framework Programme of the European Commission grant agreement no. 289437.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.forpol.2018.06.004>.

References

- Aggestam, F., Pülzl, H., 2018. Coordinating the uncoordinated: the EU Forest strategy. *Forests* 9, 125.
- Aggestam, F., Wolfslehner, B., 2013. Deliverable 3.2. Mountain forests and land use scenarios – a review and scenario development. In: ARANGE.
- Aggestam, F., Winkel, G., Pülzl, H., Sotirov, M., 2017. The EU policy framework. In: Winkel, G. (Ed.), *Towards a Sustainable European Forest Based Bioeconomy – Assessment and the Way Forward*. European Forest Institute.
- Amer, M., Daim, T.U., Jetter, A., 2013. A review of scenario planning. *Futures* 46, 23–40.
- Bizikova, L., Rothman, D.S., Boardley, S., Mead, S., Kuriakose, A.T., 2014. *Participatory Scenario Development and Future Visioning in Adaptation Planning: Lessons From Experience, Part I. IIISD Working Paper*. <https://www.iisd.org/sites/default/files/publications/participatory-scenario-development-future-visioning-adaptation-lessons-part-i.pdf>. International Institute for Sustainable Development.
- Börjeson, L., Höjer, M., Dreborg, K.-H., Ekvall, T., Finnveden, G., 2006. Scenario types and techniques: towards a user's guide. *Futures* 38, 723–739.
- Bowman, C., 1998. *Strategy in Practice*. Prentice Hall Europe.
- Bradfield, R., Derbyshire, J., Wright, G., 2016. The critical role of history in scenario thinking: augmenting causal analysis within the intuitive logics scenario development methodology. *Futures* 77, 56–66.
- Briner, S., Elkin, C., Huber, R., Grêt-Regamey, A., 2012. Assessing the impacts of economic and climate changes on land-use in mountain regions: a spatial dynamic modeling approach. *Agric. Ecosyst. Environ.* 149, 50–63.
- Carter, T.R., Rovere, L.A., E. L., 2001. Developing and applying scenarios. In: McCarthy, J.J., Canziani, O.F., Leary, N.A., Dokken, D.J., White, K.S. (Eds.), *Climate Change 2001: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom.
- Chermack, T.J., Lynham, S.A., Ruona, W.E.A., 2001. A review of scenario planning literature. *Futur. Res. Q.* 7–31.
- Council, 2014. 2030 Climate and Energy Policy Framework EUCO 169/14. Council of The European Union, Brussels.
- den Herder, M., Khadka, C., Pelli, P., Wolfslehner, B., Sandker, M., Lindner, M., Hetemäki, L., Rametsteiner, R., Muys, B., Palahi, M., 2014. Scenario Development to Strengthen National Forest Policies and Programmes: A Review of Future-Oriented Tools and Approaches that Support Policy-Making. Forestry Policy and Institutions Working Paper, FAO.
- EEA, 2007. *Land-Use Scenarios for Europe: Qualitative and Quantitative Analysis on a European Scale*. EEA Technical report. Copenhagen, European Environment Agency.
- EEA, 2009. *Looking Back on Looking Forward: A Review of Evaluative Scenario Literature*. EEA Technical Report. Brussels, European Environment Agency.
- European Commission, 2009. *White Paper - Adapting to Climate Change: Towards a European Framework for Action*. COM(2009) 147 Final. European Commission, Brussels.
- European Commission, 2014. *A Policy Framework for Climate and Energy in the Period From 2020 to 2030*. COM(2014) 015 Final. European Commission, Brussels.
- Franco, L.A., Meadows, M., Armstrong, S.J., 2013. Exploring individual differences in scenario planning workshops: a cognitive style framework. *Technol. Forecast. Soc. Chang.* 80, 723–734.
- Frittaion, C.M., Duinker, P.N., Grant, J.L., 2011. Suspending disbelief: influencing engagement in scenarios of forest futures. *Technol. Forecast. Social Change* 78, 421–430.
- Godet, M., Roubelat, F., 1996. Creating the future: the use and misuse of scenarios. *Long Range Plan.* 29, 164–171.
- Harrison, P., Dunford, R.W., Holman, I.P., Rounsevell, D.A.M., 2016. Climate change impact modelling needs to include cross-sectoral interactions. *Nat. Clim. Chang.* 6, 885–890.
- Hauck, J., Winkler, K.J., Priess, J.A., 2015. Reviewing Drivers of Ecosystem Change as Input for Environmental and Ecosystem Services Modelling. *Sustainability of Water Quality and Ecology*.
- Hetemäki, L., 2014. *Future of the European Forest-Based Sector - Structural Changes Towards Bioeconomy. What Science Can Tell Us No. 6*. EFI.
- Hoogstra-Klein, M.A., Hengeveld, G.M., Jong, D.E., 2017. Analysing scenario approaches for forest management — one decade of experiences in Europe. *Forest Policy Econ.* 85, 222–234.
- Hurmekoski, E., Hetemäki, L., 2013. Studying the future of the forest sector: review and implications for long-term outlook studies. *Forest Policy Econ.* 34, 17–29.
- Joshi, D.K., Hughes, B.B., Sisk, T.D., 2015. Improving governance for the Post-2015 sustainable development goals: scenario forecasting the next 50 years. *World Dev.* 70, 286–302.
- Kankaanpää, S., Carter, T.R., 2004. *Construction of European Forest Land Use Scenarios for the 21st Century*. http://www.sysecol2.ethz.ch/AR4_Ch04/AR4-Ch4_Grey_Lit-SOD/Ka112.pdf. Finnish Environment Institute.
- Keough, S.M., Shanahan, K.J., 2008. Scenario planning: toward a more complete model for practice. *Adv. Dev. Hum. Resour.* 10, 166–178.
- Kok, K., Biggs, R., Zurek, M., 2007. Methods for developing multiscale participatory scenarios: insights from Southern Africa and Europe. *Ecol. Soc.* 12, 8.
- Kraxner, F., Nordström, E.-M., Havlík, P., Gusti, M., Mosnier, A., Frank, S., Valin, H., Fritz, S., Fuss, S., Kindermann, G., McCallum, I., Khabarov, N., Böttcher, H., See, L., Aoki, K., Schmid, E., Máthé, L., Obersteiner, M., 2013. Global bioenergy scenarios – future forest development, land-use implications, and trade-offs. *Biomass Bioenergy* 57, 86–96.
- Kröger, M., Schäfer, M., 2016. Scenario development as a tool for interdisciplinary integration processes in sustainable land use research. *Futures* 84, 64–81.
- Maier, C., Winkel, G., 2017. Implementing nature conservation through integrated forest management: a street-level bureaucracy perspective on the German public forest sector. *Forest Policy Econ.* 82, 14–29.
- Mayerhofer, P., de Vries, B., den Elzen, M., van Vuuren, D., Onigkeij, J., Posch, M., Guardans, R., 2002. Long-term, consistent scenarios of emissions, deposition, and climate change in Europe. *Environ. Sci. Policy* 5 (2002), 273–305 (5, 273–305).
- Nakicenovic, N., Davidson, O., Davis, G., Grübler, A., Kram, T., Lebre La Rovere, E., Metz, B., Morita, T., Pepper, W., Pitcher, H., Sankovski, A., Shukla, P., Swart, R., Watson, R., Dadi, Z., 2000. *IPCC Special Report: Emissions Scenarios (SRES) - Summary for Policymakers. A Special Report of IPCC Working Group III. Intergovernmental Panel on Climate Change*.
- Porter, A.L., Roper, A.T., Mason, T.W., Rossini, F.A., Banks, J., 1997. *Forecasting and Management of Technology*. John Wiley & Sons Inc, New York.
- Pülzl, H., Hegl, K., Kleinschmit, D., Wydra, D., Arts, B., Mayer, P., Palahi, M., Winkel, G., Wolfslehner, B., 2013. *European Forest Governance: Issues at Stake and the Way Forward*. EFI Series: What Science can tell us 2. European Forest Institute.
- Roubelat, F., 2000. Scenario planning as a networking process. *Technol. Forecast. Soc. Chang.* 65, 99–112.
- Rounsevell, M.D.A., Reginster, I., Araujo, M.B., Carter, T.R., Dendoncker, N., Ewert, F., House, J.I., Kankaanpää, S., Leemans, R., Metzger, M.J., Schmit, C., Smith, P., Tuck, G., 2006. A coherent set of future land use change scenarios for Europe. *Agric. Ecosyst. Environ.* 114, 57–68.
- Seidl, R., Fernandes, P.M., Fonseca, F.T., Gillet, F., Jönsson, M.A., Merganičová, K., Netherer, S., Arpac, A., Bontemps, J.-D., Bugmann, H., González-Olabarria, R.J., Lasch, P., Meredieu, C., Moreira, F., Schelhaas, M.-J., Mohren, F., 2011. Modelling natural disturbances in forest ecosystems: a review. *Ecol. Model.* 222, 903–924.
- Seidl, R., Aggestam, F., Rammer, W., Blennow, K., Wolfslehner, B., 2016. The sensitivity of current and future forest managers to climate-induced changes in ecological processes. *Ambio* 45, 430–441.
- Setten, G., Austrheim, G., 2012. Changes in land use and landscape dynamics in mountains of northern Europe: challenges for science, management and conservation. *Int. J. Biodiversity Sci. Ecosyst. Serv. Manag.* 8, 287–291.
- United Nations Environment Programme, 2007. *Global Environment Outlook 4*. United Nations Environment Programme.
- Van Der Heijden, K., 1996. *Scenarios: The Art of Strategic Conversation*. John Wiley, New York.
- Van Der Heijden, K., 2000. Scenarios and forecasting: two perspectives. *Technol. Forecast. Social Change* 65, 31–36.
- Verburg, H.P., Schulp, C.J.E., Witte, N., Veldkamp, A., 2006. Downscaling of land use change scenarios to assess the dynamics of European landscapes. *Agric. Ecosyst. Environ.* 114, 39–56.
- Verburg, P.H., van Berkel, D.B., van Doorn, A.M., van Eupen, M., van den Heiligenberg, H., 2010. Trajectories of land use change in Europe: a model-based exploration of rural futures. *Landscape Ecol.* 25, 217–232.
- Vogelpohl, T., Aggestam, F., 2011. Public policies as institutions for sustainability: potentials of the concept and findings from assessing sustainability in the European forest-based sector. *Eur. J. For. Res.* 131, 57–71.
- Wolfslehner, B., Seidl, R., 2010. Harnessing ecosystem models and multi-criteria decision analysis for the support of forest management. *Environ. Manag.* 46, 850–861.